Reproductive Activity, Seasonal Abundance and Parasitism of the Monarch Butterfly, *Danaus plexippus* (Lepidoptera: Danaidae) in Hawaii[1]

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The monarch butterfly, *Danaus plexippus* L., first discovered in Hawaii between 1841 and 1852, has been reported from Kauai, Oahu, Molokai, Maui, Lanai and Hawaii (Zimmerman, 1948) and Niihau (Beardsley and Tuthill, 1959). The host plants of this butterfly in Hawaii include *Calotropis gigantea* (L.) Robert Brown (crown flower), *C. procera* (Jacquin) Robert Brown, *Asclepias curassavica* L. and *Gomphocarpus physocarpus* Ernst Meyer (Swezey, 1910, 1944; Zimmerman, 1948). In Hawaii this insect is considered a pest because the larvae attack crown flower grown as an ornamental plant and as a flower crop for the lei-making business. In 1972 and 1973 it was observed that the larvae caused considerable damage to the leaves of *C. gigantea*. In Manoa Valley, Waimanalo, and Waialua, Oahu, it was estimated that at least 75-90 percent of the leaves were eaten by the larvae of *D. plexippus*. The larvae were so numerous that the fully grown larvae crawled into the buildings just before pupation. To control this pest some individuals pruned the branches back heavily to get rid of the caterpillars.

The major parasite of *D. plexippus, Lespesia archippivora* (Riley), was purposely introduced from North America into the Hawaiian Islands for the control of armyworms (Swezey, 1923, 1927) probably from California (Fullaway, 1945; Pemberton, 1948), by Albert Koebele about 1898. At present this tachinid parasite is widely distributed in the Hawaiian Islands, where it is frequently found in the lowlands (Bryan, 1923, 1926, 1933; Fullaway, 1945). In the Hawaiian Islands the insects parasitized by *L. archippivora,* aside from *D. plexippus,* include armyworm, *Pseudoletia unipuncta* (Haworth); cabbage butterfly, *Pieris rapae* (Linnaeus); sugarcane leaf roller, *Hedylepta accepta* (Butler); painted lady, *Vanessa cardui* (Linnaeus); corn earworm, *Heliothis zea* (Boddie); black cutworm, *Agrotis ypsilon* (Rottemburg); and coconut leaf roller, *Hedylepta blackburni* (Butler).

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Preliminary observations made in this study indicated that the damage to foliage caused by the larvae of *D. plexippus* was severe during certain seasons and negligible in others. The present study was undertaken to obtain information that would lead to a better understanding of this phenomenon. Specifically, it was concerned with reproductive activity, adult abundance, and parasitism of *D. plexippus* by *L. archippivora*.

Materials and Methods

The reproductive activity of *D. plexippus* was measured in terms of egg production during a period of ten months, October 1972 to July 1973, on the University of Hawaii Manoa Campus. Ten potted *C. gigantea* plants were exposed to natural adult population outside the laboratory. At weekly intervals all eggs and larvae on the plants were removed and counted. The larvae, which were usually found in small numbers, were treated as eggs in the presentation of results.

Adult abundance was followed at monthly intervals on plants grown as hedge on the University of Hawaii, Manoa Campus. The adults were counted by walking a distance of 59 m and counting those that were flying around the canopy. The monthly counts were always made between 11:00 a.m. and 1:00 p.m. Because the adults flew in all directions it was possible that some individuals were counted more than once. However, since the same procedure was used at each counting occasion, these counts were considered to be adequate indices of adult abundance for a study of this kind.

The rate of parasitism of the larvae and pupae of *D. plexippus* by *L. archippivora* was determined for a period of nine months, November 1972 to July 1973, at Waimanalo and at the University of Hawaii, Manoa Campus. Samples of fourth and fifth instar larvae and pupae were taken at random at monthly intervals. They were brought into the laboratory and were placed individually in screw cap jars 6 cm diameter and 16 cm tall. The larvae were fed daily on fresh leaves of *C. gigantea* until pupation. The samples were examined daily and the number of parasites emerging from each host recorded.

Results

Reproductive activity. Data on the reproductive activity of *D. plexippus*, obtained by recording the number of eggs on *C. gigantea* plants, are shown in Fig. 1. They indicate that reproductive activity occurred from October 1972 to July 1973, but was highest during November 1972 to February 1973. Although our data cover a period of only one year, we believe that this periodicity of reproductive activity probably recurs every year. The damage to the leaves was very conspicuous, and homeowners and crown flower growers who witnessed it stated that they have observed this periodic damage for many years.

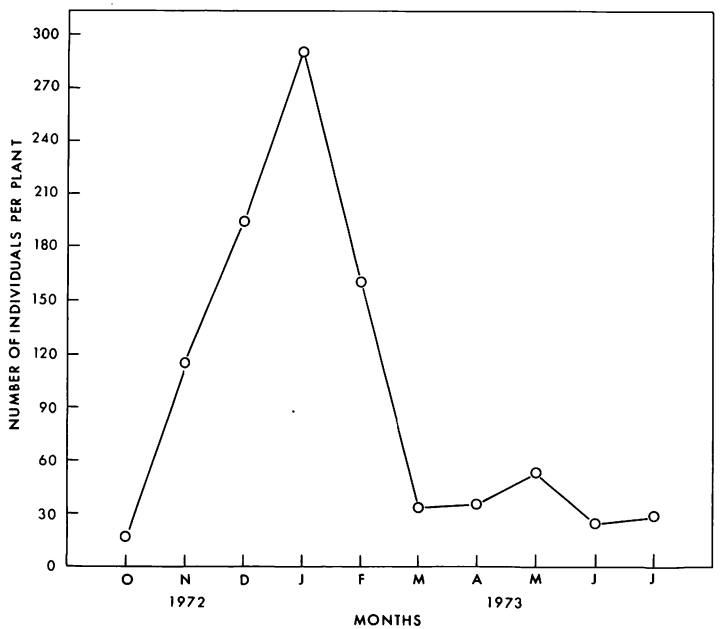

FIG. 1. Seasonal reproductive activity of *D. plexippus* as measured by egg production on *Catotropis gigantea*.

In temperate regions it is known that the reproductive activity of the migrant form of *D. plexippus* ceases during the winter months when the temperature is low and the daylength is short (Urquhart, 1960). Therefore the temperature and hours of sunshine data of Hawaii were examined in relation to reproductive activity (Fig. 2). This figure shows that reproductive activity was high during periods of shortest daylength and lowest temperature. Therefore, the relationship between low temperatures and short daylength, and the reproductive activity of *D. plexippus* in Hawaii, is opposite that of temperate areas.

Seasonal abundance of adults. Data on the abundance of adults, shown in Fig. 3, indicate that the population was highest during December, January, and February. It may be noted from Figs. 1 and 3 that the peaks of reproductive activity and adult abundance occurred almost during the same period.

Parasitism. Data on the extent of parasitism of *D. plexippus* larvae by *L. archippivora,* obtained between November 1972 and July 1973 at Waimanalo and at the University of Hawaii, Manoa Campus, are shown in Fig. 4. They show that the percentage of parasitized larvae was different in the two localities. At Waimanalo the highest parasitism (32.5 percent) was observed during November, and it decreased to zero in February. Parasitism increased to 13 percent in March, but declined to

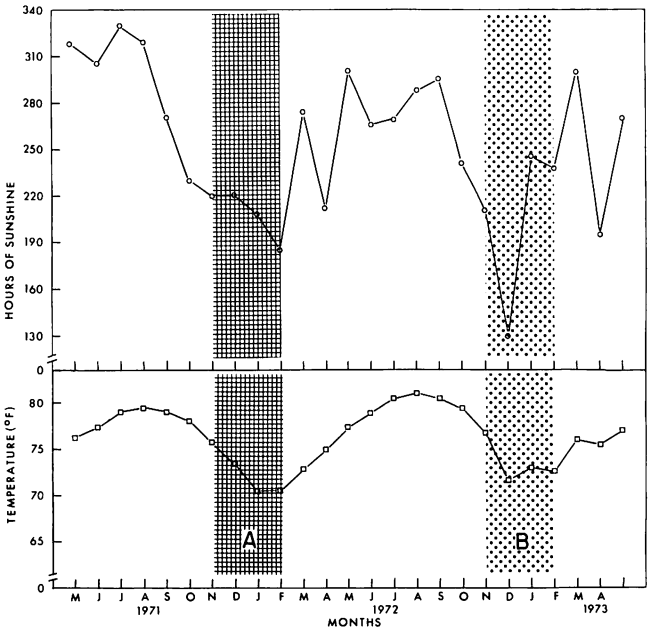

FIG. 2. Mean temperature and total hours of sunshine in relation to the reproductive activity of *D. plexippus* (metereological data for Honolulu Airport from U. S. Department of Commerce). A (hatched area) represents period of high reproductive activity based on observations. B (stippled area) represents period of high reproductive activity based on sampling data.

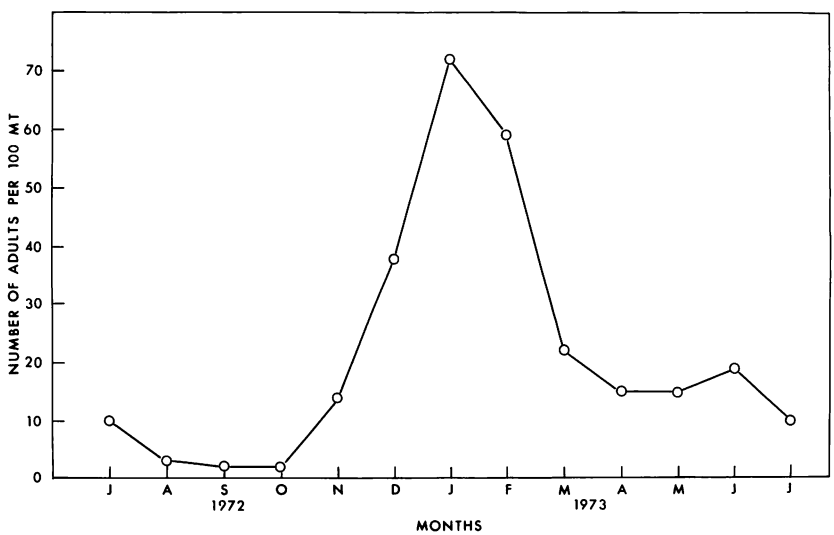

FIG. 3. Seasonal abundance of adult *D. plexippus* on the University of Hawaii, Manoa Campus. Index of abundance, expressed as number of adults per 100 linear meter of *Calotropis gigantea* plants.

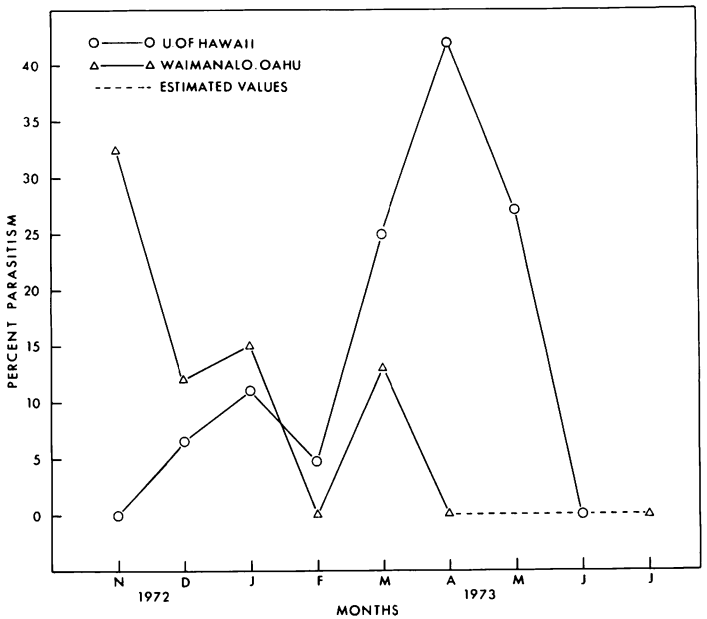

FIG. 4. Percentage parasitism of larvae of *D. plexippus* by *L. archippivora* at Waimanalo, Oahu, and on the University of Hawaii, Manoa Campus. The total number of individuals sampled during this study was 464.

zero again in April. During May and June the larval population was so low that it was not possible to obtain samples.

At the University of Hawaii Manoa Campus the percentage of parasitism was zero in November; increased during the following months, reaching the highest value of 42 percent in April, and then decreased to zero in June. Data on other months were not obtainable because it was not possible to find larvae.

Discussion

This study showed that while in temperate areas the monarch butterfly does not reproduce when the day length and temperature decrease, in Hawaii its reproductive activity increased as the temperature and day length decreased. According to Urquhart *et al.* (1968) there is a correlation between low temperature and ovarian dormancy in overwintering populations in northern California and in all of the other states of the mainland United States and Canada, with the exception of southern California and southern Florida. However, they stated that day length did not appear to influence ovarian dormancy.

The seasonal increase in the abundance of certain species of Lepidoptera other than *D. plexippus* has been observed after a period of heavy rainfall in the dry areas of Koko Head, Oahu (Swezey, 1935). This increase was attributed to the rapid growth of the host plants of these Lepidoptera following the rain. However, the phenomenon of increase and decrease of *D. plexippus* is evidently not related to host plant availability, because during the present study its major host, *C. gigantea,* was present all year round under irrigation in many residential areas of Oahu.

It was noted that the adults of *D. plexippus* were abundant during certain times of the year and not in others. The question that arises is: in the tropics does this species migrate to aggregating areas as it does in temperate areas? If it does, where are these areas?

The data on parasitism of *D. plexippus* by *L. archippivora* obtained on the University of Hawaii Manoa campus and those obtained at Waimanalo, Oahu, did not follow a consistent trend. This lack of consistency may be due to the availability of other hosts. It is known that *L. archippivora* attacks at least seven other species of Lepidoptera besides *D. plexippus* in Hawaii.

There are a number of biological and physical factors that may be involved in the abundance of the monarch butterfly in Hawaii. It is not the purpose of this paper to go into a lengthy and speculative discussion on all of these factors for it is clear that further studies are necessary before final conclusions can be made.

Summary

The reproductive activity of *Danaus plexippus* L. was high during periods of short daylength and low temperature; viz, from November to February. This phenomenon is opposite to that of temperate areas. The period of high adult abundance was during December, 1972 to February, 1973. During other months *Danaus plexippus* was scarce even though its host plant, *Calotropis gigantea,* was present all the year round. Data on parasitism by *Lespesia archippivora* showed that parasitization ranged from 0 to 42 percent at University of Hawaii Manoa Campus, and from 0 to 32.5 at Waimanalo, Oahu. Parasitism was inadequate to explain the changes in abundance of *D. plexippus.*

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